CHAPTER 3.0

PROBLEMS AND OPPORTUNITIES

3.1 Flood Risk with Current Improvements

The Sacramento area is protected from American River flooding by Folsom Dam and a system of levees. Although recent and ongoing work to improve levees on the Lower American River and modifications planned for Folsom Dam will reduce the risk of flooding, the flood risk to the Sacramento area will remain high and will fall short of the stated community flood control goal of reducing the flood risk to no greater than a 1-in-200 chance of exceedance in any year. A high level of flood damage reduction is desired for the Sacramento area because a levee system failure would lead to catastrophic flooding including the loss of human life and property.

Current estimates hold that Folsom Dam and Reservoir and the existing levee system provide protection from a flood with a 1-in-85 chance of occurring in any year. Modification to the existing levee system, known as the Common Features Project, was authorized in WRDA of 1996 and WRDA of 1999. Construction of the Common Features Project is scheduled to be completed in 2003. In addition, modifications to the Folsom Dam, known as the Folsom Modification Project, were authorized in WRDA of 1999. Construction of the Folsom Modification Project is scheduled to be completed in 2008. Following completion of these projects, the risk of flooding will be reduced to approximately a 1-in-140 chance in any year.

3.2 System Inadequacies

The potential for catastrophic damages attributable to flooding in Sacramento is magnified by the area's dependence on high levees. If the runoff volume is sufficient to fill Folsom Reservoir to its capacity, it would be necessary to match releases to inflow rates, which would result in overtopping of the downstream levees. When high levees fail, the population is significantly threatened by rapid flooding of the adjacent areas. Plate 3-1 shows the extent of flooding in the Sacramento area in a large flood event.

High levees essentially function as long dams. However, levees cannot be built with the same precision as dams. Levees are subjected to floodwaters that move at erosive velocities for miles along their waterside slope. In addition, the characteristic of the foundation soil and rock over many miles cannot be known as accurately for a levee as for a dam. Because a single weak spot in the system could potentially cause a breach and uncontrolled, life-threatening flooding, special attention must be given to the design, construction, and O&M of levee systems.

Levees can fail for several reasons, and predicting how and where they will fail is difficult. Levees have failed in cases when the stage (or height) of the water surface was significantly below the design flow. In other cases, floodflows have encroached into the design freeboard (or safety level) without levee breaching or significant damages.

The identification of potential locations and likelihood of levee failure is based on an analysis of the levee system as determined by a geotechnical assessment of levee stability. To

identify the levee's weak points, *probable nonfailure points* (PNPs) and *probable failure points* (PFPs) were defined. The PNP is the highest water-surface elevation at which levee failure is highly unlikely. Conversely, the PFP is the highest water-surface elevation at which levee failure is highly likely. For this analysis, the PNP and PFP are based on the results of field inspections and explorations, levee stability calculations, an assessment of levee performance during high water in February 1986 and January 1997, and the Common Features modifications authorized in 1996 and 1999. After the Common Features Project is completed in 2003, the levees are expected to have a high degree of reliability for their design flows.

3.3 Flood Characteristics

Areas of major flooding (flood plains) were identified based on estimated river stages, levee stability conditions during high flows, and topography. Plate 3-1 shows the likely area of inundation for a major flood. Flood problems in Natomas (located north of Sacramento) have been resolved; recently completed levee modifications give a high level of flood protection to that area.

Flooding of the Sacramento area resulting from levee failure from American River flows at channel capacity would be widespread, encompassing approximately 86 square miles of the developed Sacramento area. Water depth would range from 0.5 to 19.5 feet during a flood with a 1-in-500 chance of occurring in any year and would persist over 5–10 days. Levee failure would lead to catastrophic flooding in developed areas.

3.4 Future Without-Project Flood Risk and Damage

3.4.1 Change in Flood Risk

With the North Area Local Project and the Common Features Project in place, the flood risk to Natomas, north of Sacramento, will be reduced to approximately a 1-in-400 chance in any year. The alternatives under consideration as part of this evaluation would not significantly affect the flood protection for Natomas.

The without-project condition includes completion of the Common Features Project, the Folsom Modification Project that includes outlet modification and surcharge operation, and a reoperation plan reducing the variable flood control space from 400,000 670,000 acre-feet to 400,000–600,000 acre-feet. Table 3-1 shows the conditional probabilities of exceedance of major flooding along the Lower American River. Authorized flood control improvements will reduce the exceedance probability to 0.007 (1-in-140 chance per year) by 2008. The chance that a storm with a 50-year return period would result in flooding is approximately 2 percent, given the design of levees and uncertainties in hydrology and hydraulic evaluations. The likelihood that flooding will not occur is very high—approximately 98 percent. For larger (more rare) storms, the chance of levee failure and flooding increases.

As discussed in Chapter 2, "Affected Environment," when Folsom Dam outlets are enlarged, Folsom Dam will have the ability to make releases in advance of reservoir inflow based on forecast inflows that are large enough to be a flood risk. Under this operation, the water supply pool would be partially emptied in advance of the impending storm. This advance

release operation would result in a further reduction in the without-project flood risk. Because an advance release operation has not been developed, and no agreements have been made to institute advance release, this study cannot forecast whether advance release will actually be instituted.

TABLE 3-1. Probability of Nonfailure from Specific Events [a] under Without-Project Conditions [b]

Storm		Percent Chance of Exceedance			Percent Chance of Nonexceedance		
1-in-X Chance per Year (X)	Exceedance Probability	No Advance Release	Without-Project Advance Release[3]	Upper Bounds Advance Release[4]	No Advance Release	Without-Project Advance Release[3]	Upper Bounds Advance Release[4]
50	2.0	2	1	1	98	99	99
100	1.0	21	14	12	79	86	88
200	0.5	62	52	46	38	48	54
400	0.25	91	86	82	9	14	18

[a] A particular frequency flood event (e.g., a 100-year flood) can result in various river stages within the Lower American River levees. If river stage exceeds the ability of the levees to hold back the water, levee failure and flooding of the Sacramento area will occur. Uncertainties exist regarding several parameters that determine the stage in the Lower American River. These parameters include amount of runoff and peak discharge from Folsom Dam. The biggest unknown parameter is the volume of runoff into the regulating reservoir from a particular frequency rainfall event. These uncertainties are estimated, which results in a range of river stages that may occur for any particular frequency flood event. Many different possible combinations for a particular frequency flood event are evaluated, and the percentages of the combinations that result in flooding are calculated.

[b] These conditions include Folsom Dam modifications and associated work in 2007. They do not include advance release that may be implemented through the flood management plan update.

[c] Advance release would create between 0 and 190,000 acre-feet of temporary flood space, with 100,000 acre-feet being the most likely.

[d] Advance release would create between 100,000 and 250,000 acre-feet of temporary flood space, with 140,000 acre-feet being the most likely.

Advance release is part of the without-project condition through update of the Flood Management Plan. The advance release is still under development. Advance release (or prerelease) has the potential to reduce flood risk. To illustrate the possible impacts of the addition of prerelease to the without-project condition flood risk, three scenarios were developed. The first scenario is that advance release would not occur, possibly because of currently unanticipated problems. For the second and third scenarios, this study provides a cursory estimate of the potential amount of additional flood space that could be created under advance release. With the second or most likely scenario, advance release could create 100,000 acre-feet of additional flood space. For R&U purposes, it was estimated that at worst no additional flood space could be gained and at best 190,000 acre-feet could be gained under this scenario. This is the moderate, without-project condition advance release. Moderate advance release would reduce the exceedance probability to 0.0061 (1-in-164 chance per year). The third scenario provides the maximum extent of additional flood space that could be gained under the most optimum advance release condition. With this upper bounds advance release, approximately 140,000 acre-feet of additional flood space would be gained. Similarly for R&U purposes, it was estimated that at worst 100,000 acre-feet of additional flood space would be gained and at best 250,000 acre-feet could be gained. Upper bounds advance release would reduce the exceedance probability to 0.0056 percent (1-in-179 chance per year). This advance release scenario is optimistic to the extent of being unlikely given the current understanding of the limits of advance release operation. It however, is presented as a maximum possible advance release scenario for purposes of providing a check on economic feasibility of alternatives, if upper bounds advance

release is later to be found implementable. Table 3-1 portrays the without-project conditions for all three advance release scenarios.

3.4.2 Damages

Major flooding in an urban environment has many adverse consequences, including effects on public health and safety, monetary damages, and loss of real property. Damageable property in the Sacramento flood plain consists of commercial, industrial, residential, and public buildings valued at nearly $28 billion. Damages to buildings from levee failure during a storm with a 1-in-200 chance of occurring in any year (currently authorized projects in place, no advance release) would amount to approximately $10 billion. Damages during a storm with a 1-in-400 chance of occurring in any year would amount to approximately $12 billion.

As a result of damage to infrastructure and buildings, the adverse effects on the day-to-day business activities of Sacramento would be substantial. Many businesses would be forced to close, at least temporarily, resulting in lost revenue and wages. Rebuilding or relocating homes, businesses, and related infrastructure would require substantial natural and financial resources. Because Sacramento is California's capital and center of government, a major flood and the resulting effects on day-to-day business would have far-reaching effects outside the area damaged by the flood.

Average annual equivalent damages are the expected value of damages for a given economic condition. They are determined by weighing the estimated damages from varying degrees of flooding with their probability of occurrence. Existing average annual equivalent flood damages are estimated at $67 million ($80 million with no advance release, $62 million with upper bounds advance release). Future average annual flood damages are estimated at approximately $71 million ($84 million with no advance release, $65 million with upper bounds advance release).

In addition to the building damage suffered in the Sacramento area, transportation and power transmission disruption could adversely affect governments and businesses regionally and throughout California. A major flood would result in significant disruption and potential damage to Interstates 5 and 80, which are major north-south and east-west transportation corridors in the State. State Highways 16, 99, and 160 and U.S. Highway 50 also would be affected, as would Sacramento's light rail system, Sacramento International Airport, Amtrak passenger service, and the Union Pacific Railroad commercial rail lines. In addition, damage to the metropolitan area's power grid would likely disrupt the distribution of electricity.

The effect of levee failure and resultant flooding on human life would depend on the flood magnitude, number of people at risk, flood warning time, depth of flooding, time of day, and availability of evacuation routes. Because nearly 270,000 people reside in the flood plain of the American River, it would be reasonable to expect drownings during a very large flood. The number of fatalities would depend on the time of day, the warning time, and the suddenness of the levee breach. In addition to loss of life, major flooding could result in life-threatening injuries and the spread of waterborne infectious diseases.

Flooding would result in significant releases of toxic and hazardous substances from aboveground tanks and drums containing heating oil, fuel oil, liquid propane, and kerosene; agricultural chemicals such as herbicides, pesticides, solvents, and fertilizers; many commercial and industrial chemicals; and untreated wastewater. Widespread flooding also could result in groundwater contamination. In addition, flooding would likely result in the deposition of large quantities of flood-related debris, most of which would have to be collected and hauled to local landfills.

Flooding also would have effects on urban landscaping and wildlife, and special-status wildlife and plant species could be affected by inundation.

3.5 Ecosystem Restoration Problems and Opportunities

Flows in the Lower American River are regulated by Folsom Dam and other water resource developments in the basin. The combination of mining, development, flood plain constrictions (including bridges, levees, diversions, and the parkway system), dam construction, and flow modifications over the past 150 years has altered the physical processes that sustain ecosystem values, thereby contributing to significant degradation of the Lower American River ecosystem. These changes will likely continue, further reducing riparian, wildlife, and related habitat values along the lower river. There is a significant need to preserve the resources remaining and, as much as possible, restore lost resource values. The following sections address some of the problems and opportunities in this ecosystem.

3.5.1 High Water Temperature

High water temperatures in the Lower American River affects the spawning and other life stage behavior of fish species of highest management concern, including fall-run chinook salmon and Federally threatened Central Valley steelhead, resulting in reductions of the species' natural production populations in the Lower American River. Historically salmon and steelhead were able to migrate to upstream areas where there was cooler water temperatures in the summer and fall. Since construction of Folsom and Nimbus Dams, these species are confined to an area with less suitable water temperatures for spawning and rearing. Potential restoration activities are limited to improving habitat conditions for these species in this reach.

Water temperatures can reach unsuitable levels for juvenile salmon and steelhead trout during spring and summer, especially in dry and critically dry water years. High summer water temperatures severely limit natural steelhead production in the Lower American River because juvenile steelhead reside in fresh water for a full year or more before migrating to sea. Significant reductions in Folsom Reservoir storage in dry and critically dry years can cause water temperatures to exceed suitable levels for chinook salmon eggs survival in October and November, adversely affecting both natural and hatchery production.

Providing a flexible mechanism for manipulating the timing, temperature, and rate of flow released from Folsom and Nimbus Dams, especially during late spring to early fall, when seasonal temperatures are highest, would produce the most immediate and effective temperature reduction for fish habitat restoration.

3.5.2 Flood Plain Connectivity

High flood plains produced by the deposition of sandy sediments from upstream hydraulic mining during the Gold Rush are disconnected from the ordinary flow of the river, except during very high flow events. Without a regular cycle of frequent inundation, which brings water to the unnaturally high terraces and shallower water tables, native plant species cannot regenerate adequately. Species favoring infrequent inundation and many nonnative, invasive species have taken advantage of the altered system and reduced the ecological integrity of the flood plain ecosystem.

Removing excess soil to reestablish more frequent inundation from the river, Bannon Slough, and one of the borrow channels facilitates a more natural hydrologic cycle for native plant establishment and subjects a larger area to frequent inundation. An additional benefit of lowering flood plain elevations is the reduction in isolated low areas on the flood plain that may trap native fish during high flows. This removal work results in healthy, diverse riparian communities and overall habitat improvement.

Restoration opportunities are constrained to the area between the levees. It is infeasible to construct setback levees due to the extensive urban development on the landside.

3.5.3 Shallow Aquatic Fisheries Habitat

Shallow aquatic vegetation consisting of emergent and woody vegetation in combination with low-lying inundated areas has largely disappeared from the Lower American River. These areas provide valuable habitat for native fish species and are a critical link in restoring ecological integrity to the Lower American River corridor.

Channel downcutting between the high flood plain banks results in a lack of shallow aquatic habitat—an important resource for juvenile fish rearing—along channel edges. This process also results in a lack of shallow, slow-water side channels and other off-channel aquatic habitats that are important to both fish rearing and fish spawning.

High-quality fish rearing habitat can be created by cutting benches to lower bank elevations or by constructing shallowly submerged fill benches along the channel edges and placing instream woody material and planting riparian vegetation near the shoreline.

3.5.4 Nonnative Plant Species

Because nonnative plant species are better adapted to dry conditions, the dry upland conditions of high flood plain benches and the modified hydrologic cycle allow invasive nonnative plant species to outcompete native species. High flood plain benches generally lack vegetative cover and diversity. To varying extents, invasive nonnative plant species cover significant areas in the Lower American River corridor. These flora displace native plant species that wildlife in the corridor depend on, thereby reducing the biodiversity of the ecosystem.

The Lower American River Task Force has identified the removal of nonnative plant species as an important goal in restoring the ecological health of the Lower American River.

Creating more frequent inundation, in combination with removing invasive nonnative species and planting native riparian plants, would enhance ecological function and values in the river corridor.

3.5.5 Riverbank Substrate

Dredger tailings in the form of bars and deposits along the riverbanks and on the flood plain provide a poor substrate for riparian plants and less-than-optimal fish and wildlife habitat values. Upstream dams have eliminated downstream transport of sediment and slowed the development of substrate used by plants for colonization.

Removing and redistributing large river cobble, in combination with reintroducing fine-grained bank material, may foster conditions more suitable for regenerating native riparian vegetation.

3.5.6 River Channel Bathymetry

Deep pools are found in several locations where the river has captured abandoned gravel mining pits. These pools provide habitat for predator fish that prey on juvenile salmon.

Filling excessively deep pools, lowering the flood plain, developing side channels, and disposing of dredger tailings could eliminate predator habitat, thus increasing juvenile salmon survival.

3.5.7 Loss of Seasonal Wetlands

The shallow and slow-moving waters of seasonal wetlands provide ideal spawning and resting habitat for native fish, including Sacramento splittail, salmon, and steelhead. Seasonal wetlands connected to the active river flood plain also contribute to the ecological biodiversity of the corridor. Since efforts to harness the river for flood control purposes first began, the function of many of these wetlands has been lost. As the flows of the river have become more regulated and sediment has been prevented from being deposited in the lower reaches, the riverbed elevation has lowered, leaving the previously connected wetlands abandoned on the high terraces of the remaining flood plain. Restoring the ecological function of these wetlands would increase suitable habitats available for the benefit of native fish populations.

3.5.8 Loss of Native Riparian Forest Plant Community

Riparian forests on the Lower American River are limited to narrow, steep strips adjacent to the river, NEMDC Bannon Slough, and the borrow channels adjacent to levees. Most of these areas are old generation forest. Riparian forests are characterized by layers of habitat provided by dense trees, shrubs, and grasses that provide a transition zone between aquatic and upland terrestrial areas. Because riparian forests have a high diversity of habitat, they support a corresponding high diversity of fish and wildlife species. Expansion of these forests has been limited to these areas through historic land management practices and the reduction in areas of frequently inundated soils required for their natural germination, dispersal, and growth. Opportunities include reconstructing seasonally inundated flood plain terraces by reducing steep

slopes adjacent to waterways. In addition, planting native plant species allows the riparian forest plant communities to regenerate naturally.

3.5.9 Loss of Native Oak Woodlands

Before construction of levees and conversion of land into agriculture and urban development, much of the higher elevations in the Lower American River flood plain had expanses of oak woodlands. Although remnants of these woodlands remain in small patches, they are greatly fragmented. The quality of these areas for wildlife habitat is a direct function of the presence of large, contiguous oak woodlands. Reestablishing oak trees (*Quercus* spp.) and their associated species, such as elderberry (*Sambucus mexicana*) and black walnut (*Juglans hindsii*), would provide excellent habitat for both terrestrial and avian native wildlife species of the river corridor.

3.5.10 Loss of Native Grasslands

Most of the grasslands once covering the drier soils of the flood plain have been converted to other uses since the area was settled. Most remaining grasslands have been infested and fragmented by large stands of nonnative invasive species or have become covered with more woody species as the historical, cultural practice of burning grasslands has been eliminated from the landscape. Grasslands provide habitat for many small mammals that inhabit the river corridor. Their open, uncanopied nature is an ideal characteristic for raptor species looking for forage from adjacent trees. Restored grasslands can outcompete nonnative invasive species and are an important element of maintaining the food web of the flood plain ecosystem.

3.5.11 Lack of Forage and Cover for Native Wildlife Species

The corridor is host to a wide diversity of waterfowl, other birds, and small mammals. Some species found along the Lower American River are raccoons, voles, rabbits, foxes, deer, coyote, beaver, and river otter. Some surveys have counted more than 150 different avian species on the California Exposition flood plain alone. Restoring diverse habitats on the flood plain would provide the forage and cover needed to sustain these diverse populations.

3.5.12 Loss of Shaded Riverine Areas

Shaded riverine areas with low, overhanging vegetation cool the water temperature, and downed woody material (e.g., branches and trunks of trees) provides areas for spawning salmon and steelhead to rest. As the river channel has incised over time, riparian vegetation has been left high on the terrace and clinging to steep banks, leaving it inaccessible to anadromous fish species. The steep banks prevent the low vegetation from attaching itself to soil so that it may regenerate. Recreating shaded riverine areas would benefit native fish species and restore riparian vegetation to the river's edge.

3.5.13 Fish Stranding

The flood plain has a few areas that trap native fish when overbank flows recede from the flood plain. Examples of these areas are the mining pits at Arden Bar and Urrutia. Providing positive drainage toward the river or toward Bannon Slough would reduce this threat to the native fish species.

3.6 Other Water Resources Problems and Opportunities

3.6.1 Water Supply

Water supply and conveyance are concerns in Placer, El Dorado, Sacramento, and San Joaquin Counties. In summary, (1) Placer County has sufficient water supplies to meet future demands but will need distribution facilities; (2) El Dorado, Sacramento, and San Joaquin Counties will require additional supplies to meet future demands; and (3) El Dorado, Sacramento, and San Joaquin Counties will require additional facilities to convey this water to growing service areas. The Bureau has assessed these water supply needs and potential solutions as part of its American River Water Resources Investigation.

3.6.2 Hydropower

Demands in California for power are expected to grow in the foreseeable future. The growth rate is expected to be greater in the northern portion of the State, including the Sacramento Municipal Utility District service area. The need for electric power in the Sacramento area is expected to exceed locally available supplies in the near future.

3.6.3 Recreation

The Upper American River canyon, Folsom Lake, and Lower American River provide prime and unique resources for outdoor recreation. Future recreation demands will increase substantially in all these areas because of the expected growth of the surrounding large population base.

The Lower American River has been officially designated as a component of both the Federal and State Wild and Scenic Rivers Systems. Paralleling the Lower American River in the Sacramento area is the American River Parkway—a 5,000-acre greenbelt used by approximately 5.3 million visitors each year. Sacramento County estimates that the number of visitors using the parkway will increase to more than 9 million by 2020. Under the Wild and Scenic River classification, the Lower American River is designated as a "recreational" river rather than a "wild" or "scenic" river because of the level of public accessibility and the degree to which the natural conditions of the river have been modified.